

UNITED STATES DEPARTMENT OF THE INTERIOR  
GEOLOGICAL SURVEY

SIDESCAN-SONAR IMAGE OF INNER SHELF OFF FOLLY BEACH, S.C.

by

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## INTRODUCTION

The Folly Beach, S.C. 1995 sidescan-sonar data were collected as part of an extensive multidisciplinary, multi-institutional study of the South Carolina coastal system (Figure 1). The study is being conducted along an area of the South Carolina coast that is dominated by barrier islands and associated inlets, focusing on eight of the systems. Ultimate goals of the study are to establish a statewide-sediment budget, quantify longshore sediment transport gradients, determine the effects of modifying inlet channels, and establish the interaction of adjacent beach and inlet systems using nearshore physical properties, regional geology, and shoreline geometry. Five dominant themes have been identified in this study: geologic framework, shoreline changes, sediment volume, sediment transport, and inlet dynamics. The sidescan-sonar mosaic presented herein contributes mainly to the first two themes.

It is important to look at the exchange of sediment between inlets, inner shelf, and shoreface in order to better understand the processes controlling coastal changes, beach erosion/accretion. The offshore ebb-tidal deltas offer a primary control on the erosion and deposition of the local system, as well as on the barrier island(s) down-current, which is to the south for the study area (Fitzgerald and Hayes, 1980). It is unknown, however, how the geologic framework for each area influences the erosion/depositional patterns (Harris and others, 1994). Framework variations coupled with variations in processes controlling erosion may explain the differences in degree of storm damage along the coast.

Folly Beach is one of three areas undergoing detailed study along 60-km of shoreline centered near Charlestown Harbor, S.C. (Figure 1). Folly Beach is one of two barrier islands, Folly and Kiawah, adjacent to Stono Inlet. Folly Beach offers a view of a mesotidal (2-4m) barrier-island-inlet system.

The sidescan-sonar data show sediment accumulation patterns, identify possible sources and redeposition sites of borrow material, and show some general onshore to offshore sediment dispersal patterns.

## DATA COLLECTION AND PROCESSING

In July 1995, a 10x4 km area of the Folly Beach shoreface and inner shelf was imaged using a Klein 100 kHz sidescan-sonar system (Figure 2). These data were collected during a 10-day period aboard the Coastal Carolina University research vessel MS Coastal. Line spacing for the 48 lines incorporated a roughly 20% overlap to insure adequate coverage of the sea floor. A sample rate of 7.5

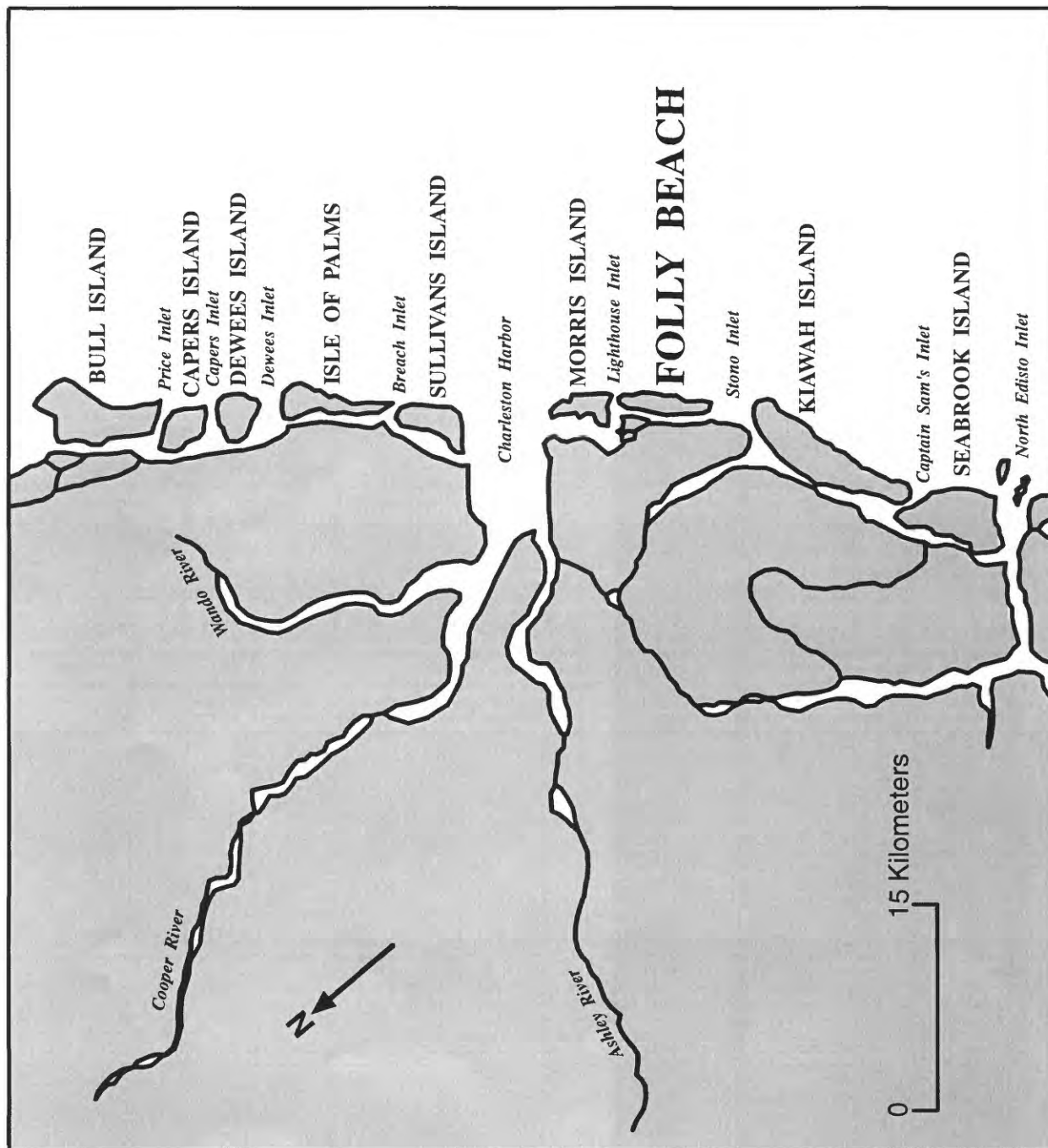


Figure 1 : Location map for Folly Beach, S.C.

Figure 2 : Ship trackline map for Folly Beach sidescan-sonar survey gathered in July 1995.

pings/second was used, yielding a 200 m total swath width, resulting in a 0.09m/pixel resolution in the across-track direction. A QMIPS data acquisition system digitally logged the sonar data. All bathymetric data were collected with a shipboard ODEM 12 kHz fathometer in conjunction with navigation.

Navigation was collected by use of a Differential Global Positioning System (DGPS), resulting in a  $\pm 3$ m accuracy in ship's position. The distance between the ship's position and the position of the towfish can be estimated within 5 meters based on the length of cable out and the depth of the fish below the sea surface. Horizontal deviation of the fish from the ship's trackline, however, is not known.

The sidescan-sonar data were processed following the methods of Danforth and others (1997; Appendix). This suite of processing routines addresses the geometric and radiometric distortion inherent in the sonar data. These include slant-to-ground range correction, destripe, and beam pattern correction. The slant-range algorithm removes the water column artifact from the sonograph; the destripe routine replaces anomalously low amplitude pings with an average of adjacent pings; and the beam pattern routine accounts for variation in beam intensity with range.

The seaward 30 lines displayed significant banding (or striped noise) due to wave-induced towfish instability. To suppress the noise, a striped noise removal technique was applied to these lines. A low-pass smoothing-spatial filter (15 lines x 31 pixels) was applied to suppress noise and reduce the high-frequency content of the image (Paskevich, 1992b,c). A high-pass filter (1 line x 31 pixels) was also applied to enhance the image detail. The two images, low-pass filter and high-pass filter, were then combined with equal weight and normalized by centering it (the combined image) in an 8-bit range. The data were oriented in a UTM (Universal Transverse Mercator) projection using a WGS84 reference ellipsoid and mapped at a resolution of 1 m/pixel using a revised, rapid mapping routine (MAPIT, Paskevich, 1996). Two files are created, mapping in every other line.

Adjacent swaths of mapped sidescan imagery were registered by aligning distinctive features in overlapping areas (PCI software). This reduces offset between swaths due to navigational error. The mosaic was then constructed by digitally stenciling adjacent, overlapping swaths to incorporate the best resolved parts of both swaths. Every other swath was sequentially added to the image to produce the final digital mosaic (Figure 3). Tone matching, accomplished by applying a stretch to the image, was performed to compensate for gain setting changes during acquisition. Black represents low backscatter, and white represents high backscatter in the final digital mosaic. Bathymetry was then registered to and overlain on the image by graphically correlating the Cartesian coordinates of the bounds of both images.

Figure 3 : Image-enhanced sidescan-sonar mosaic for 1995 survey area of the shoreface and inner shelf off Folly Beach, S.C. Bathymetric contours are in meters. Bathymetry is based on data collected in this survey.

## APPENDIX: Processing History for the Folly Beach 1995 Sidescan Sonar Mosaic

This appendix is intended to describe briefly the processing procedure but specifically to document the steps and the parameters unique to the processing of the Folly Beach data set. For a more complete discussion, see Paskevich (1992a,b,c,1996), Denny (1995), Johnson and Helferty (1990), and Chavez (1986). In documenting the processing steps and parameters, specifics are mentioned, to which the reader is referred to the aforementioned references to obtain a full explanation.

- Xsonar (Danforth, 1997):

\*Altitude correction: Insures that the sonar is tracking bottom (sediment/water interface) and not strong acoustic anomalies in the water column.

\*Demultiplex (median filter): The filter outputs the median value of every four pixels along track and every three pixels across track, yielding an average 1:1 aspect ratio for each pixel for the given ping rate and swath width. This reduces the size of the output data file, and removes anomalously high and low amplitude values. The 1:1 aspect ratio produces a square, 1x1, pixel relative to x-y distance.

\*Slant Range Correction: Converts straight line distance from sonar to seafloor (slant range) to true (horizontal) ground distance from nadir. Additionally, the water column travel time is removed, and pixel duplication in the near range is performed to prevent image distortion.

\*Beam Pattern: Accounts for beam intensity degradation with respect to range due to attenuation and grazing angle effects, yielding a more coherent image from near to far range.

\*Destripe: Corrects for low amplitude returns for individual pings due either to system anomalies or tow-fish vertical motion.

\*Merge Navigation: After editing the navigation for spurious data points, the navigation file is merged with a sonar file, assigning unique latitude-longitude values to each pixel.

The parameters unique to this data set are:

Klein data input = 8 bit, swath width = 200 m.,  
beam pattern 600, navigation interval = 2 min.

The final processed file is

--> [.sdb]

where:

s = slant range, d = destripe, b = beam pattern

\*Convert the file(s) to raw format

select "convert" in Xsonar

--> [.whp] = image file  
[.whp.hdr] = header file

- This step converts the raw imagery and associated ASCII header file(s) (\*.whp and \*.whphdr, respectively) to NetCDF format (Paskevich, 1992a):

A sample batch file "doMips" follows (512 = number samples in each file):

```
#!/bin/csh
foreach file(*whp.hdr)
set lines = 'wc -l < $file'
set tmpfile = $file:r
set prefix = $tmpfile:r
mipssonar -i $file:r -o $prefix.cdf -h $file -s 512
-l $(lines) -c -y 1900
end
```

--> [.cdf]

where:

```
-i = input file -o = output file -h = ASCII header
-s = number of samples -l = number of lines
-c = fish course output as heading information in
    sonar file
-y = base year value to be added to two digit year
```

- Filter to subdue striped noise arising from pitch of ship and fish due to bad weather, lines 18-42 (Paskevich (1992b,c))

A sample batch file "dofilter" follows:

```
#!/bin/csh
foreach file (*.cdf)
set temp = $file:r
echo "working on $file"
filter -i $file -o $temp.lpf -l -b 15,31
filter -i $temp.lpf -o $temp.hpf -h -b 1,31
wtcombo -i $temp.hpf,$temp.lpf -o $temp.wco
-c 1,1 -a -127
end
```

--> [.wco]

- Mapit (Paskevich, 1996): Woods Hole image processing system program which computes geographic coordinates for each sidescan-sonar pixel within sidescan-sonar image file. Geographic coordinates (lat/lon) are converted to a user supplied map projection and earth model. For this data set, UTM coordinates (eastings and northings) and a WGS84 spheroid were selected. The image coordinate is then computed, which places the projected sidescan sonar data in geographic space.



A sample run-line follows:

```
mapit -i fn.wco -o fn.map -c mapit.dat -r 0.39,1.0
```

where:

- r = input resolution (m/pixel). For these data = .39 (= 200 m. swath width/512 pixels)
- 1.0 = the output resolution
- i = input file
- o = output file
- c = control file

mapit.dat file contains bounds used:

```
79d 58.5'W    32d 36.5'N
79d 48'W      32d 41'N
```

--> [.map]

Note: each "master" file (eg. even.map and odd.map) contains alternate lines which are used to stencil adjacent lines during creation of the final digital mosaic

#### - Apply filters

mode 3: applies a 3x3 median filter to WHIPS image

mode 5: applies a 5x5 median filter to WHIPS image

filter: applies a 3x3 zero replacement filter to WHIPS image

Sample run lines are:

```
mode3 -i Mapeven.map -o Mapeven.mode3 -z -Z
```

```
mode5 -i Mapeven.mode3 -o Mapeven.mode5 -z -Z
```

```
filter -i Mapeven.mode5 -o Mapeven.filter -b 3,3 -z
```

--> [.filter]

where:

- i = input file
- o = output file

- z = apply filter only when middle value is zero

- Z = zero values not included when computing mode value (Paskevich,1992c)

- b = size of boxcar in lines and samples

- GCPworks: Create digital mosaic utilizing PCI Remote Sensing software program GCPWorks. Collect ground control points and apply rubber sheeting to align adjacent sidescan swaths. Draw stencil area around sidescan data to be retained and combine swaths to build complete digital mosaic.

- Georeference the final digital mosaic given map bounds, projection, reference spheroid, and pixel resolution. (Geographic information is not maintained when importing a file into PCI.)

## ACKNOWLEDGEMENTS

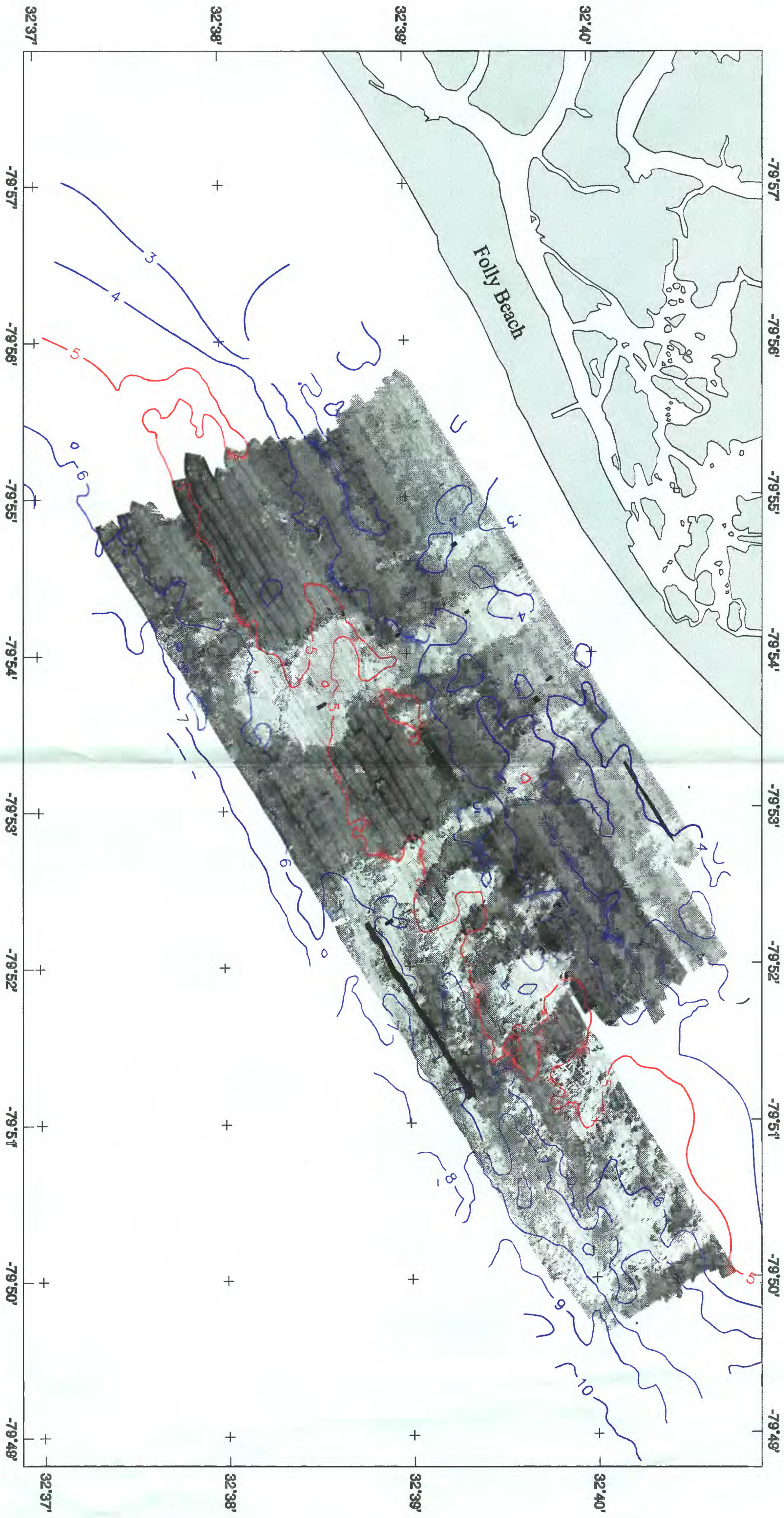
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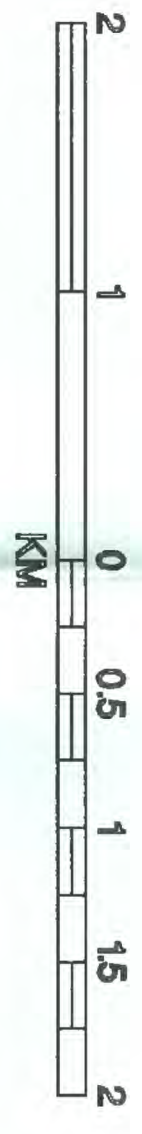
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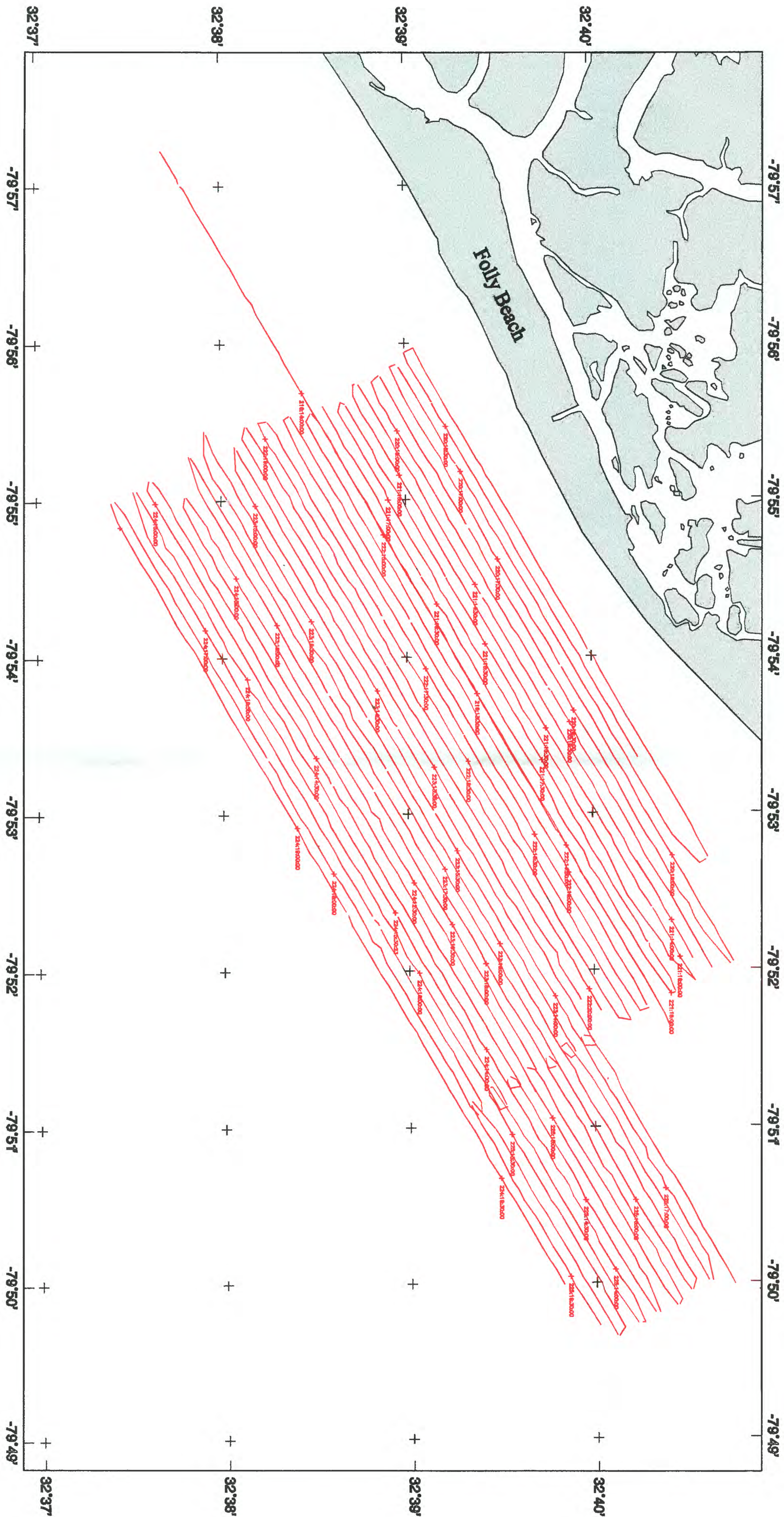




UTM Projection  
WGS84 Ellipsoid  
Contour Interval 1m







UTM Projection  
WGS84 Ellipsoid

